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Title: THE HYDROLOGICAL EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL ASSESSMENT OF THE GEOLOGY AT LOS ALAMOS NATIONAL LABORATORY, TECHNICAL AREA 54, MATERIAL DISPOSAL AREA J

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Los Alamos
NATIONAL LABORATORY

THE HYDROLOGICAL EVALUATION OF LANDFILL PERFORMANCE (HELP) MODEL ASSESSMENT OF THE GEOLOGY AT LOS ALAMOS NATIONAL LABORATORY, TECHNICAL AREA 54, MATERIAL DISPOSAL AREA J

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INTRODUCTION

Purpose:

- Conduct HELP model variations in weather data, profile characteristics, and hydraulic conductivities for major rock units
- Compare and contrast the results of simulations
- Obtain an estimation of leakage through the landfill from the surface to the aquifer
- Evaluate contaminant transport to the aquifer utilizing leakage estimation

Significance:

- Helps assess risk to the general public from waste operations
- Required by regulators in planning and closure of landfills
  - As well as other operations that could potentially contaminate groundwater
- Aids in the determination of monitoring periods

Figure 1: Location map of Mesita del Buey at TA-54 and vicinity. Darker shaded portions of the map illustrate canyon areas, while portions illustrate mesa tops, and patterned areas indicate material disposal areas. Modified from Reneau et al., 1998.

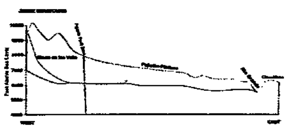

Figure 3: : Conceptual model of groundwater flow and recharge. This figure illustrates the relationships from the Sierra de los Valles to the Rio Grande. The Valles Caldera is located further to the west. All spatial relationships are approximated. Modified from ESH-19 (1994).

Figure 2: Photograph of the southern side of Mesita del Buey, taken from within Pajarito Canyon.

Site:

- Located on northwest part of Mesita del Buey, Los Alamos National Laboratory, Technical Area 54, Material Disposal Area J (MDA-J)
  - Figures 1 & 2
- Historically used to dispose of nonhazardous, administratively controlled wastes
- Main aquifer depth: 330 m at the western end and 259 m at the eastern end of mesa
- Groundwater flow: eastward towards Rio Grande, 7.2 km away from site (Figure 3)
- Groundwater age: ^{14}C data indicates groundwater is 6k -10 k years old (Keating, 2000)

THE HELP MODEL

Why the HELP Model?

- Designed to assess landfill performance
- Capable of estimating the magnitude of various fluid components
  - The volume of leachate produced
  - The thickness of water-saturated soil above any liners emplaced within the landfill

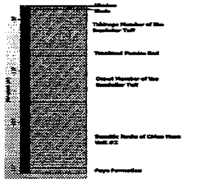

Figure 4: Screen capture of pit profile taken from within Visual HELP 2.2. The vertical axis shows depth beneath ground surface in meters. Names to the right indicate names of geologic formation layers incorporated into the model.

DATA REQUIREMENTS

Climatic Information:

- Evapotranspiration
  - Evaporative zone depth and average wind speed
  - Maximum leaf area index and growing season dates
- Weather
  - Precipitation, temperature, and solar radiation data

Soil and Landfill Design:

- Landfill general information
  - Area, slope, and rate of subsurface inflow
- Layer and layout design information
  - Layering beneath surface (Figure 4)
    - Soil properties and thickness associated with each layer
  - Engineering controls

Weather Generator:

- Temperature and precipitation
  - User may enter from 1-100 years worth of monthly mean temperature and precipitation data
- Solar radiation data
- Calculated from the temperature and precipitation values

Assumptions:

- Does not take into account extensive fracture system at research site
- Assumes that runoff does not occur from surrounding areas onto the landfill
- Does not consider rainfall intensity
- Assumes that vegetative growth and decay can be characterized using a model developed for crops and perennial grasses
- Does not consider aging of profile

RESULTS

Trial Descriptions:

- Trial 1
  - Weather Generator was used to obtain data for Albuquerque, NM for 8 years
- Trial 2
  - Weather Generator was used to obtain data for Albuquerque, NM for 100 years
- Trial 3
  - Database within the Weather Generator was edited to include site-specific average monthly values
- Trial 4
  - Files generated by Weather Generator were replaced with formatted files containing site-specific precipitation and weather data for 8 years
- Trial 5
  - Basalt layer within the profile was modeled as a barrier soil liner instead of a vertical percolation layer as in other trials
- Trial 6
  - Maximum hydraulic conductivity values for 4 profile layers were used
- Trial 7
  - Minimum hydraulic conductivity values for 4 profile layers were used

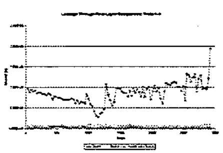

Figure 5: Trials 1-4 monthly leakage data comparison. Trial 1 is Albuquerque eight-year weather data, Trial 2 is Albuquerque 100-year weather data, Trial 3 is Los Alamos monthly weather data, and Trial 4 is Los Alamos daily weather data. Trial 2 dataset was broken up into twelve groups of eight-year data and one group of four-year data.

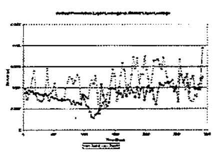

Figure 6: Monthly leakage rates through the final layer of the HELP model profile for Trials 4 & 5. The profile for Trial 4 contained the Basaltic Rocks of Chino Mesa Unit #2 with vertical percolation layer parameters, while the profile for Trial 5 contained the Basaltic Rocks of Chino Mesa Unit #2 as a barrier layer.

Trial Results:

- Values for Trial 1 & the first 8 years of Trial 2 were identical
- Values for Trials 1 & 3 were almost identical
- Precipitation, evapotranspiration, runoff, and leakage rates varied little among Trials 1, 2, & 3
  - Average leakage rates for Trial 1 was 2.65E-9 m/d, for Trial 2 was 1.25E-8, and Trial 3 was 1.27E-8
- Precipitation, evapotranspiration, runoff, and leakage rates were higher for Trial 4 (Figure 5)
  - Average leakage rate for Trial 4 was 1.51E-6 m/d
- Trial 5 showed overall greater leakage rates than Trial 4 (Figure 6)
- Barrier soil within the HELP model is modeled as always saturated, whereas vertical percolation layer saturation begins at zero
- Trial 6 displayed higher leakage rates in the beginning and became progressively lower as simulation continued (Figure 7)
- Trial 7 showed lower leakage rates in the beginning and became progressively higher as simulation continued (Figure 7)
- Hydraulic head building on top of the layer within Trial 7 and less of this occurrence in Trial 6

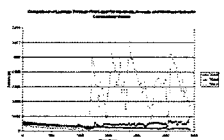

Figure 7: Monthly leakage rates through the final layer of the HELP model profile for Trials 4, 6, and 7. Trial 4 utilizes average hydraulic conductivity values. Trial 6 expresses the maximum hydraulic conductivity values, and Trial 7 uses the minimum hydraulic conductivity values.

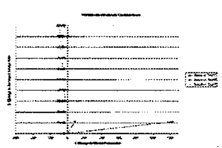

Figure 8: Sensitivity analysis for Trials 5, 6, and 7 compared to Trial 4. Trial 5 changed a layer within the profile to a different type of layer, and Trial 6 & 7, changed the saturated hydraulic conductivity to maximum and minimum values within four different layers.

Statistics:

- Coefficient of correlation was conducted on chosen weather data related combinations
  - Trial 4 showed little correlation with Trials 1 or 3
  - Trial 1 showed high correlation with Trial 3 and the first eight-years of Trial 2
- Histograms were developed for weather data related trials
  - Indicated that only Trial 4 was significantly different from the other three trials
- Sensitivity analysis was conducted on trials that changed model parameters (Figure 8)
  - When model parameters are increased, the percent change in leakage rate is only about 10%
  - When the change in the model parameter is negative, the percent change in leakage is higher, reaching almost 100%

Contaminant Transport:

- Soil sampling at the site revealed the presence of lead (0.20 mg/L) and barium (1.2 mg/L) in concentrations below regulatory limits (Dye, 2001)
  - The amount of leachate that would reach the aquifer in 30 years would be 5.8 m^3 for one pit
  - Assuming no speciation, Trial 4 average leakage rates, and an aquifer of 1 m thick, concentration of lead would be 3.31E-3 mg/L
  - Drinking water limit for lead is 15 ppb
  - Unrealistic estimate but illustrates that leachate transport is minor

Conclusions:

- The HELP Model is useful to assess landfill design alternatives or the performance of a pre-existing landfill
- Model results using site-specific data incorporated into the Weather Generator (Trail 4), varied significantly from generalized runs (Trials 1-3)
  - consequently, models that lack site-specific data should be used cautiously
- Data from this study suggest that there will not be significant downward percolation of leachate from the surface of the landfill cap to the aquifer -leachate transport rates have been calculated to be slow

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